New York UNIVERSITY
Tandon School of ENGINEERING

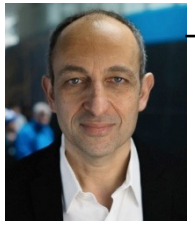
Wearable Computing for Mental Well-Being

Rose T. Faghih

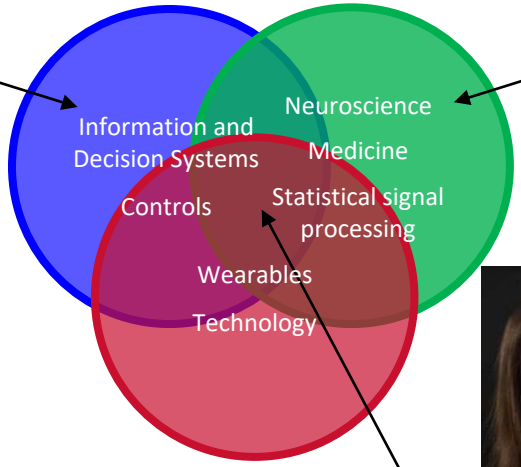
Department of Biomedical Engineering

Supported by NSF 1755780 & NSF 1942585/2226123

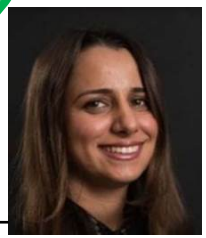
Computational Medicine for Closed Loop Therapy



Munther Dahleh, PhD
(MIT)



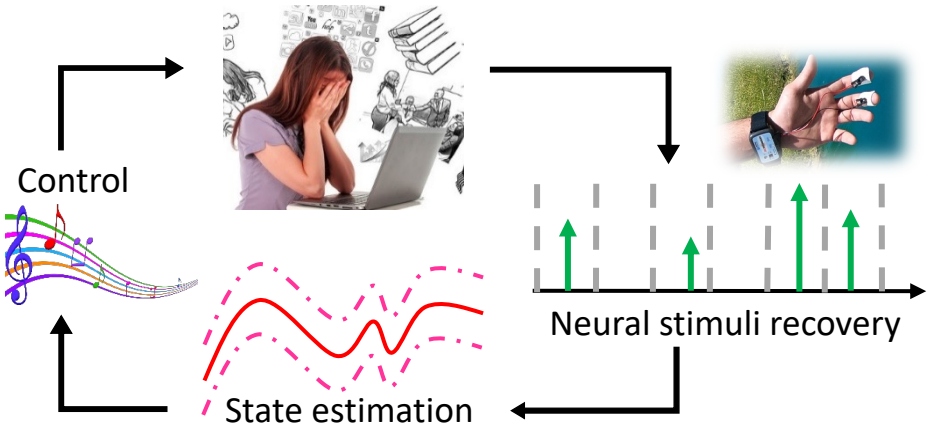
Emery Brown, MD, PhD
(MIT, Harvard)



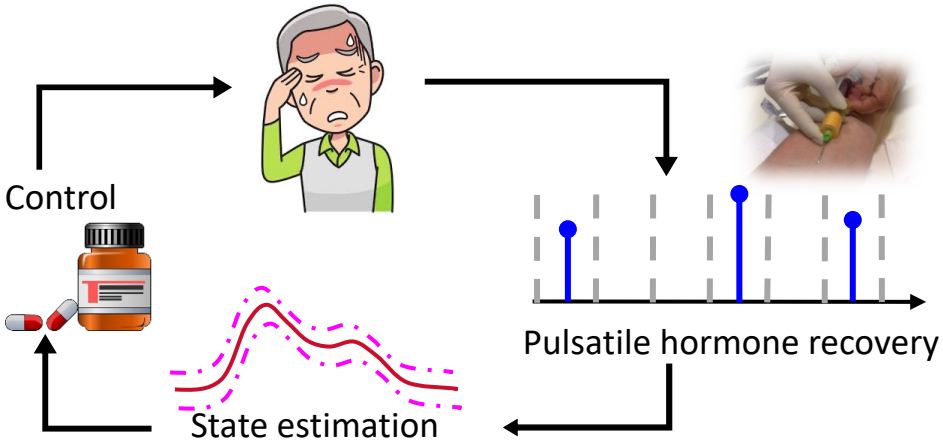
Rose Faghih, PhD (MIT '14)
Postdoc MIT BCS, Jun 2014-Dec 2016
Assistant Prof. UH ECE, Jan 2017-Jan 2022
Associate Prof. NYU BME, Since Jan 2022

- **Infer** neural **stimuli** underlying **pulsatile** (rapidly fluctuating) physiological signals (e.g. skin conductance, blood cortisol levels)
- **Estimate** an unobserved cognitive **state** based on underlying pulsatile stimuli
- Design **control** strategy to maintain neural state within a desired range

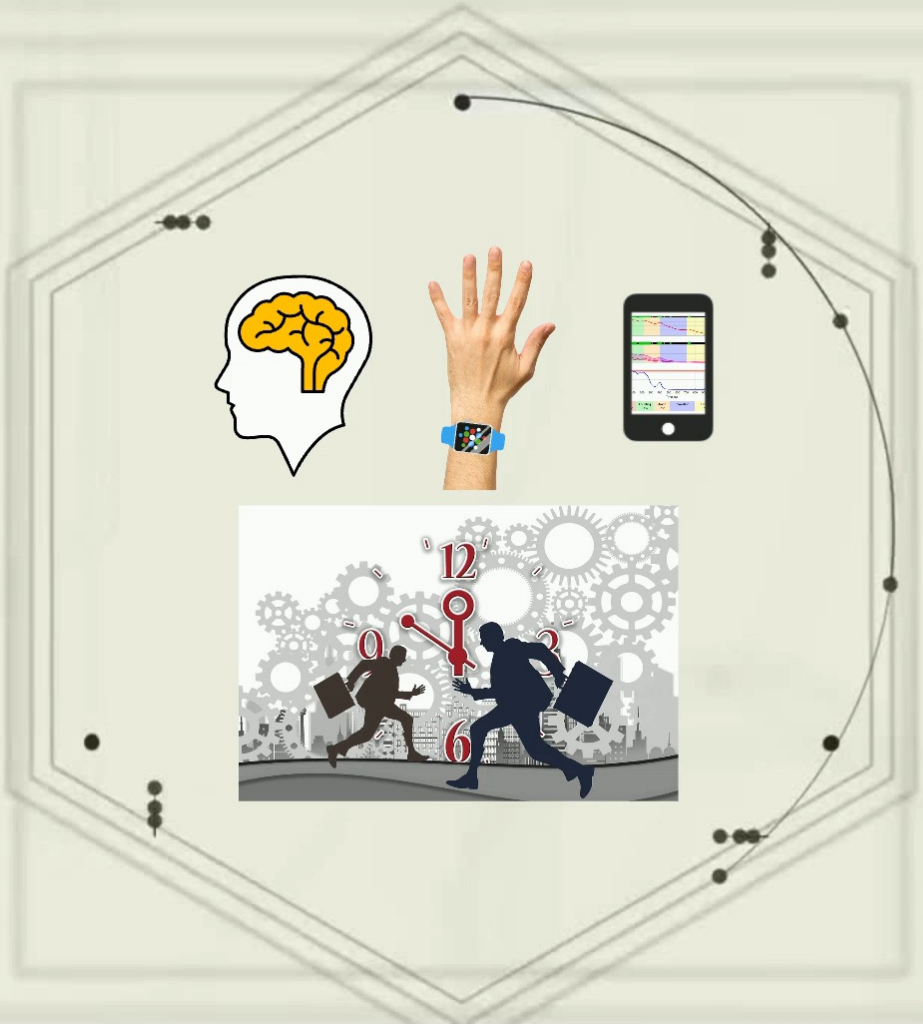
Stress Estimation from Skin Conductance



Energy Estimation from Blood Cortisol



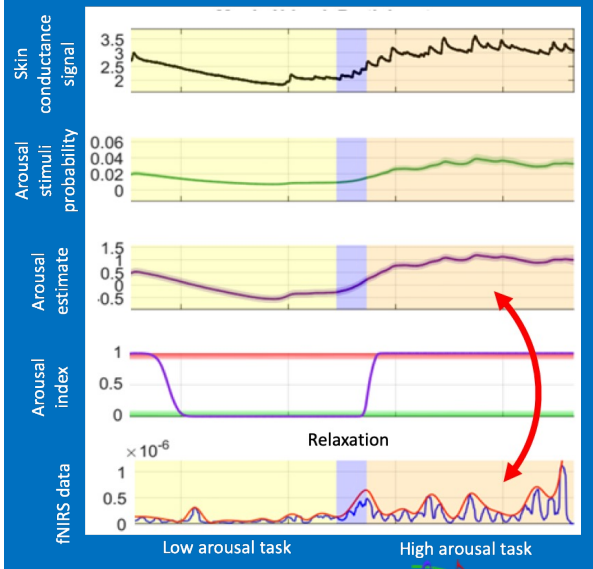
Wearable-Machine Interface Architectures

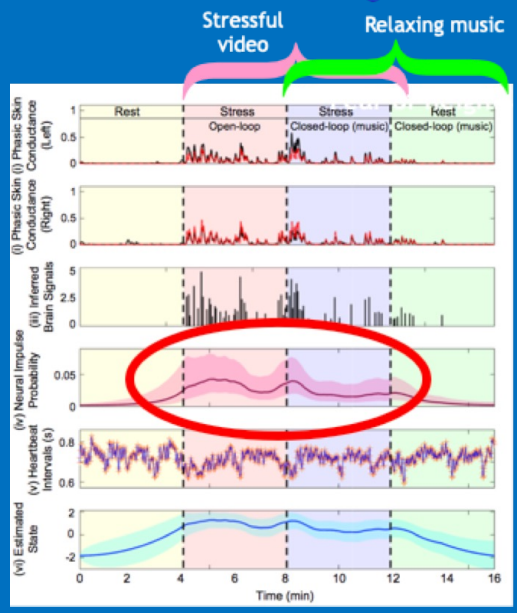


[Wearable-Machine Interface Architectures Video]

Smartwatch-Brain Interface Architectures for Neurocognitive Stress

- What if Our Smartwatches Could Track Our Brain States?
  - **Wearable device** to infer brain activity from **peripheral** physiological signals
    - **Infer neural stimuli** underlying physiological signals
    - **Estimate** an unobserved brain state from underlying pulsatile stimuli
    - **Apply control** mechanism to maintain neural state within a desired range
    - Current gold standard – direct brain activity monitoring (e.g., EEG)
- Selected to MIT Technology Review's 2020 Innovators Under 35 list (FuturoProssimo has predicted this technology has a high potential for a Nobel prize) and 2020 NSF CAREER Award on MINDWATCH
- Ability to recover brain activity
  - Arousal estimates from skin conductance match Functional near-infrared spectroscopy **(fNIRS) blood flow (brain imaging)** over prefrontal cortex
- Empirical demonstration of the viability of regulating arousal via music (**subject-selected relaxing music**) based on observations from skin conductance and cardiac activity

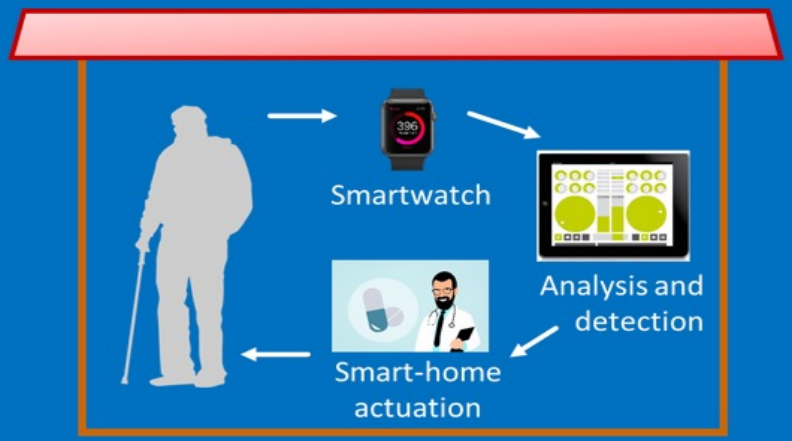




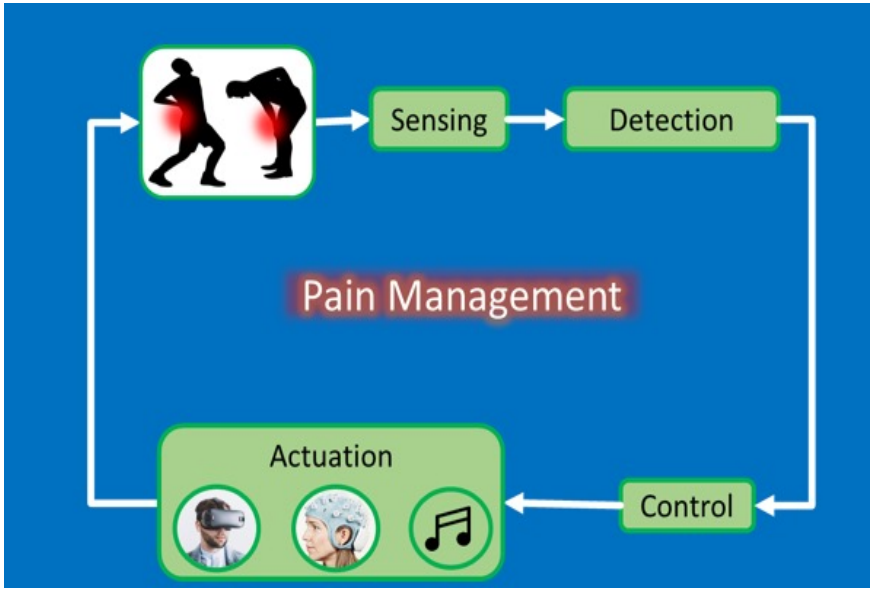
Applications

Optimize Productivity in Smart Workplaces

Maximize Cognitive Engagement and Learning in Online and In-class Environments



Aging in Place



MINDWATCH Demonstration

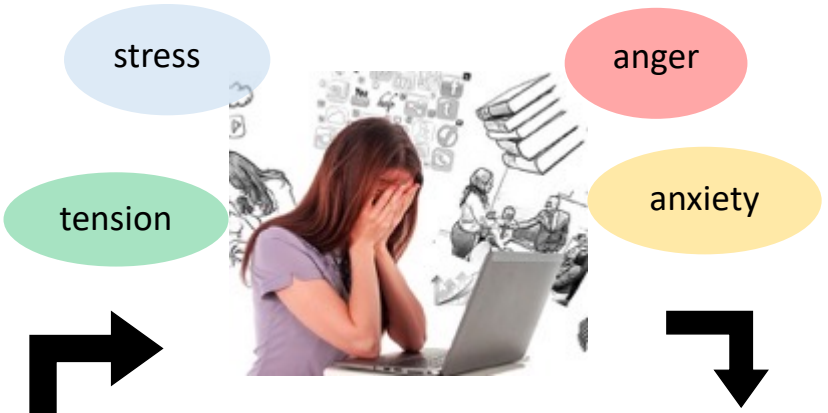
MINDWATCH Demonstration

Conclusions

Wearable devices to infer brain activity from peripheral physiological signals

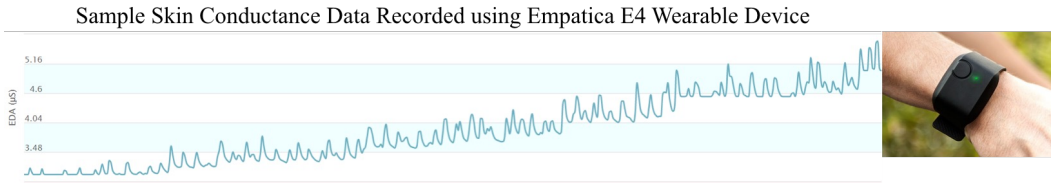
Contributions:

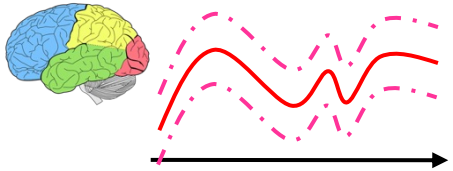
- Infer the neural stimuli underlying pulsatile physiological signals (e.g. skin conductance, blood cortisol levels)
- Estimate an unobserved neural state from inferred neural stimuli (e.g. arousal, energy)
- Applying control to maintain the unobserved state within a desired range



control

neural stimuli recovery

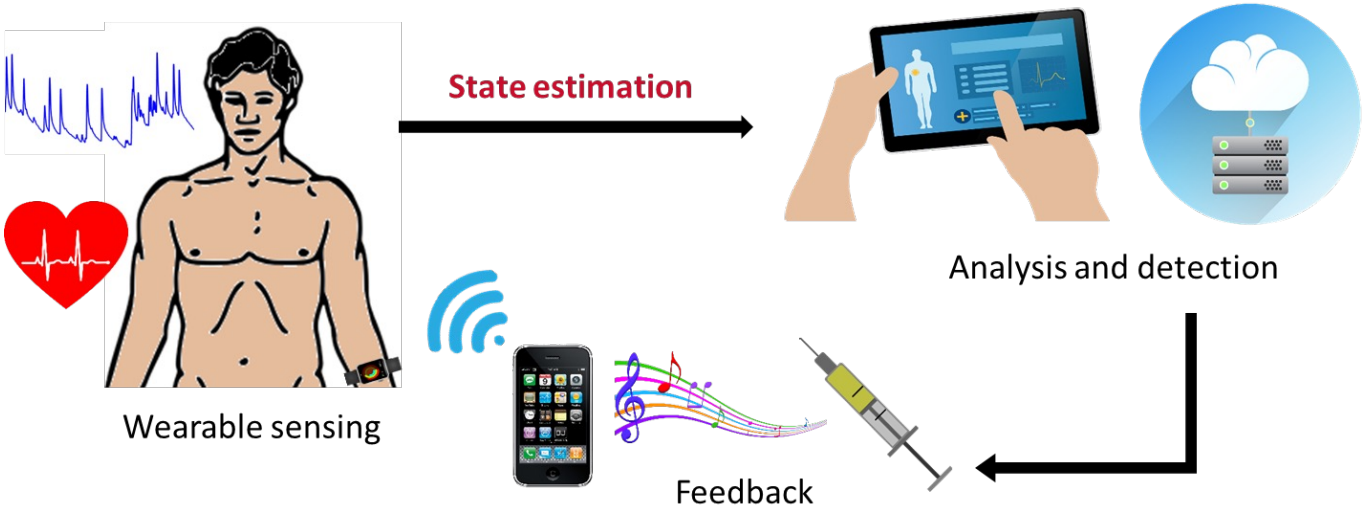




neural state estimation

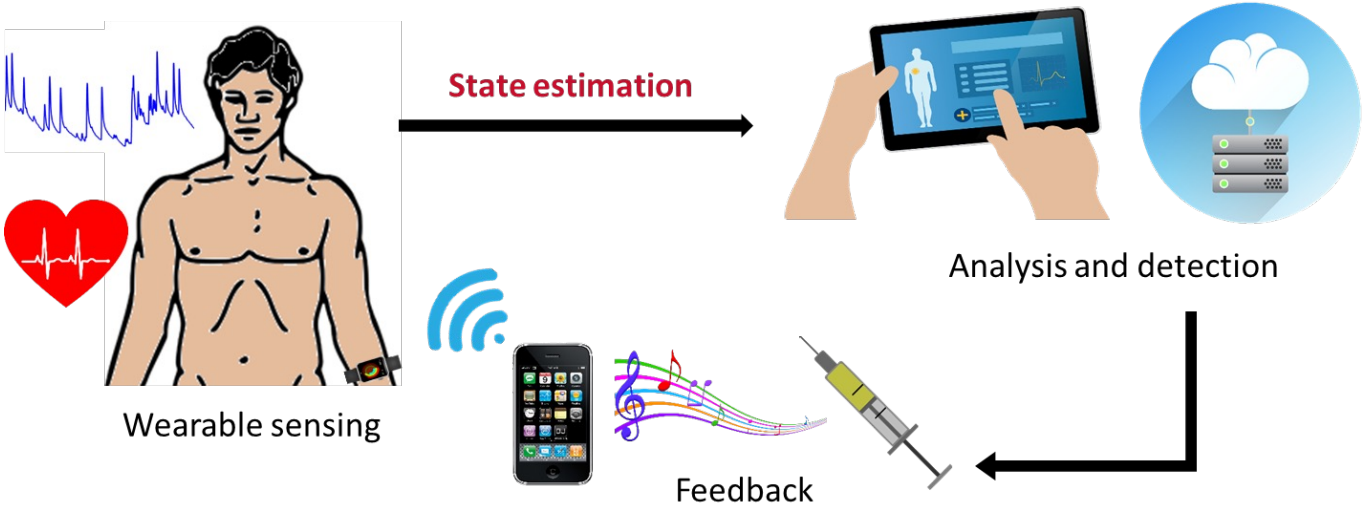
Future Directions: Medical Cyber-Physical Systems

- Estimate and regulate unobserved quantities within the human body
- Future work would involve **multi-dimensional** cases and building **time-varying** models
- Implement **activity**-based and **environment**-based correction for real-world implementation
- Smartwatches to decode brain states
- Smartwatches to regulate brain function in a non-invasive safe manner



Vision: Wearable Computing for Healthcare Delivery

- **Integration** of sensors & algorithms to provide **clinically relevant** information
  - **Biosensing wearables**
    - Fusion of biochemical and traditional bioelectrical sensors
  - **Biomedical data science** algorithms
- Use **dynamic biosensor data** to **detect**, **manage**, and **prevent health conditions** in everyday settings
  - Enable real-time identification of those at-risk for disease
  - Deliver **precise** and **customized** care
  - Enable at-home remote healthcare delivery



Thank You

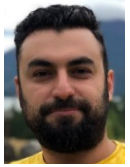
Supported by NSF CPS Program
under grants 1755780
and 1942585/2226123.

Joint work with current and former PhD students

Md. Rafiul Amin
Deconvolution

Dilranjan Wickramasuriya
Estimation

Saman Khazaei
Estimation



Hamid Fekri Azgomi
Control

NYU TANDON SCHOOL OF ENGINEERING

Computational Medicine Laboratory
PI: Rose T. Faghih - rfaghih@nyu.edu